Physiological Seed Performance of Local Aceh and National Release Variety of Rice (*Oryza sativa* L.) to Water Stress

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Abstract
Global warming causes changes in rainfall patterns causing lack of water for cultivation (IPPC, 2007). About 50% of the rice cultivation area in the world has water shortages which becomes limiting factors of production (Bouman, 2009), hence the need early detection for drought-resistant varieties with seed physiological test. The experiment carry out at Laboratory Seed Technology and Industry of Agriculture Faculty Syiah Kuala University from April to June 2015. The experiment in split plot design 3X10 with 3 replication and standing roll wet paper germination method used. Amount of 2250 seed are used for physiological seed performance test. Water stress condition induced with PEG 6000 0%; 12.5%; 25%. Local genotype and national released variety of rice used in this experiment are Bo Santeut, Romokot, Sanbei, Pade mas, Aweuh, Inpari 16, IR 64, Situ Patenggang, and Towuti. Concentrations of Polyethilene Glicol 6000 (PEG 6000) have significant effect on all physiological parameter. Some local rice Aceh genotypes potentially to be cultivated on dry lands to cope water stress conditions.
Key words: PEG 6000, water stress, rice, germination

Introduction

Early detection of genotype / rice varieties that are tolerant of water stress need to be done early to save time and costs. Water stress induced by osmotikum treatment using various materials such as NaCl and PEG as well as other compounds that can affect water potential solution to create water stress condition. Genotypes / varieties with good physiological response under conditions of water stress is expected to grow well in water stress land. PEG 8000 at a concentration of 15% has been able to show a different response to water stress resistance in rice (Ballo *et al*, 2012). PEG 6000 at 25% is effective for detecting drought resistance in rice germinated seeds (afa *et al*, 2013). the physiological response of local and national released varieties are used to determine the resistancy of genotypes and varieties to grow in conditions of water stress. so that it can be estimated for chances of genotype and varieties which can grow on dry land. Genotypes and varieties that are able to make osmotic adjustment by producing various compatible compounds are resistant to drought conditions (Redillas et al, 2013).

Materials and Methods

Procedure

The experimental design used is Split Plot 3 x 10 with 3 replications. There are 2 factors studied which were PEG 6000 concentration with 3 levels (0%;12,5%;25%) as the main plots and varieties (Bo Santeut, Romokot, Sanbei, Pade Mas, Aweuh and 5 National Varieties that are : Inpari 16, IR 64, Situ Patenggang, Margasari, Towuti) as a subplot. Standing rolled wet paper germinated seed test use in this experiment which consist of 90 units . every unit consists of 25 seeds. The germination method used is standing rolled wet paper seed test.

The parameters observed in this study are:

1. Potential Seed Growth (PSG)

$$\text{PSG (\%)} = \frac{\sum \textit{Grow indicated Seed}}{\sum \textit{Total test seed}} \times 100\%$$

2. Germination Percentage(GP)

$$\text{GP (\%)} = \frac{\textit{Storngly Germinating seed Observation I} + \textit{Number of strongly germinating seed Observation II}}{\sum \textit{Total test seed}} X\ 100\%$$

3. Seed Growth Rate (SGR) = $\frac{N_1}{t_1} + \frac{N_2}{t_2} + \ldots + \frac{N_n}{t_n}$ (%/etmal)

4. Growing simultaneity (GS)

$$\text{GS(\%)} = \frac{\sum \textit{Number of Strongly germinating seed between observation 1 and observation 2}}{\sum \textit{tested seed}} X\ 100\%$$

5. T50 (Time needed for 50% germination)

$$T_{50} \text{ (days)} = ti + \left(\frac{n50\% - ni}{nj - ni}\right) (tj - ti)$$

6. Dry Weight of Normal germinated seed (DWNS)
dried in oven at temperature of 60C for 3 x 24 hours. Then weighed and expressed in grams.

Data Analysis
Analysis of variance was performed separately for each treatment and each variety (ANOVA). Means were tested by Honesty significant difference at p = 0.05 (HSD = 0.05).

Results and Discussion
The effect PEG 6000 concentration and Variety on potential seed growth, germination Percentage, seed growth rate, growing simultaneity, time for 50% germination and dry weight of normal germinated seed. honesty significant difference test use to see significancy between level of each factors as seen in table 1 below.

Table 1. Average Value of Parameters Effect by Water Stress with PEG 6000

Treatment PEG 6000	**The parameters observed**					
	PSG (%)	**GP (%)**	**SGR (%/etmal)**	**GS**	**T50 (Day)**	**DWNS (g)**
Kontrol	9.88 b (97.20)	9.80 c (95.60)	3.75 c (13.60)	9.80 c (95.60)	2.74 b (7.00)	0.9 a (0.31)
12.5%	9.81 b (96.00)	9.24 b (86.00)	3.29 b (10.59)	8.65 b (76.67)	2.98 c (8.4)	0.92 b (0.35)
25%	9.01 a (82.93)	1.00 a (0.93)	0.74 a (0.06)	0.71 a (0)	1.02 a (1.4)	1.00 c (0.51)
HSD 0,05	0.23	0.14	0.02	0.13	0.11	0.01

(Figures in brackets are the original data, outside the brackets is the data transformation using the arc. $\sin\sqrt{x + ½}$)

Table 1 shows value of rice seed germination physiological parameters that indicate the difference due to the influence of water stress effect of concentration of PEG 6000, affected the physiological performance of rice seed. Because of decreasing in potential water at concentration of PEG 6000 0%, 12.5% and 25% become -0.03, -0,49 and -0,99 MPa. Make limiting water imbibition in seed. these results in accordance with Suardi 2010, Ballo 2012, Afa 2013 where increasing concentrations PEG 6000 effected lower of physiological perfomance of rice seeds. Increasing concentrations of PEG 6000 also resulted increasing dry weight of normal Germinated seed at 12,5% PEG 6000. In the above table looks at a concentration of 12.5% increase in weight when compared with control of without PEG 6000 (-0.03 MPa). Physiological responce of water stress involves several process simultaneously. First response of reception signal stress of water by roots or embryos, followed by a decrease in turgor pressure, decreased potensial water and process osmotic adjustment, it turn to reduce the growth rate (Lisar et al, 2013) some of the biochemical process can also occur in water stress condition, the decrease transien metabolism and important enzymes. active metabolism of some soluble compound production such as MDHA, Glybet, Proline and tocoferol as well as an increase in anti-oxidants such as SOD, CAT, APX, POD, GRX, MGHAR and decrease the accumulation of ROS with active anti-oxidants. under water stress condition are also affected by molecular response in the form of gene expression – such as a gene that produces ABA, LEA, DSP, RAD, Dehidrin which can affect germinated seed tolerance to water stress.

Effect of genotype and variety of physiological parameter of rice seed shows at table 2 below.

Table 2. Average Value of Physicological parameter of Rice Seed

Varieties	**Parameter Assisted**					
	PSG (%)	**GP (%)**	**GS (%/etmal)**	**SGR (%)**	**T50 (Day)**	**DWNS (g)**
Bo Santeut	9.84 b (96.44)	6.76 c (63.56)	2.70 b (8.76)	6.64 ab (61.33)	2.10 a (4.89)	0.87 a (0.26)
Romokot	9.91 c (97.78)	6.72 c (62.67)	2.65 b (8.39)	6.69 ab (62.22)	2.14 a (5.11)	0.91 b (0.34)
Sanbei	9.77 ab (95.11)	6.76 c (63.56)	2.66 b (8.53)	6.71 ab (62.67)	2.10 a (4.89)	0.94 c (0.38)

Pade Mas	9.89 c (97.33)	6.59 b (60.44)	2.58 b (7.96)	6.34 ab (56.44)	2.14 a (5.11)	0.95 d (0.41)
Aweuh	9.84 b (96.44)	7.23 c (64.89)	2.66 b (8.13)	6.60 ab (60.44)	2.83 b (8.22)	0.90 b (0.32)
Inpari 16	9.20 ab (85.33)	6.99 c (65.33)	2.77 b (9.13)	6.71 b (62.67)	2.43 a (6.33)	0.99 e (0.48)
IR 64	8.78 a (80.89)	6.23 ab (54.67)	2.50 b (7.54)	5.85 ab (48.89)	2.21 a (5.56)	0.96 d (0.42)
Situ Patenggang	9.96 c (98.67)	6.85 c (62.67)	2.66 b (8.40)	6.66 ab (61.78)	2.12 a (5.00)	0.96 d (0.43)
Margasari	9.57 ab (91.56)	6.89 c (63.56)	2.61 b (8.18)	6.40 ab (57.33)	2.18 a (5.33)	0.93 c (0.36)
Towuti	8.92 ab (80.89)	5.79 a (47.11)	2.18 a (5.78)	5.26 a (40.44)	2.21 a (5.56)	0.99 e (0.48)
HSD 0.05	1.01	0.75	0.30	0.77	0.68	0.02

(Figures in brackets are the original data, outside the brackets is the data transformation using the arc. sin√x + ½)

Table 3. The average value of the potential seed grow as effect of interaction between the PEG 6000 with varieties(%)

	PEG 6000 (%)		
Genotype/Variety	**0**	**12,5**	**25**
Bo Santeut	9.62 a (92.00)	9.96 a (98.67)	9.96 a (98.67)
Romokot	9.82 a (96.00)	9.96 a (98.67)	9.96 a (98.67)
Sanbei	9.82 a (96.00)	9.89 a (97.33)	9.61 a (92.00)
Padi Emas	9.89 a (97.33)	9.75 a (94.67)	10.02a (100)
Aweuh	9.89 a (97.33)	10.02a (100)	9.60 a (92.00)
Inpari 16	9.96 a (98.67)	9.96 a (98.67)	7.68 a (58.67)
IR 64	9.96 a (98.67)	9.89 a (97.33)	6.49 a (46.67)
Situ Patenggang	9.89 a (97.33)	10.02a (100)	9.96 a (98.67)
Margasari	10.02a (100)	9.75 a (94.67)	8.93 a (80.00)
Towuti	9.96 a (98.67)	8.91 a (80.00)	7.88 a (64.00)
HSD 0.05		3.91	

Tabel 4. The average value of the germination percentage due to interaction between the PEG 6000 with varieties

	PEG 6000(%)		
Genotype/Variety	**0**	**12.5**	**25**
Bo Santeut	9.62 b (92.00)	9.96 b (98.67)	0.71 a (0)
Romokot	9.62 b (92.00)	9.82 b (96.00)	0.71 a (0)
Sanbei	9.82 b (96.00)	9.75 b (94.67)	0.71 a (0)
Pade Mas	9.82 b (96.00)	9.24 b (85.33)	0.71 a (0)
Aweuh	9.75 b (94.67)	9.75 b (94.67)	2.18 a (5.33)
Inpari 16	9.96 b (98.67)	9.82 b (96.00)	1.18 a (1.33)
IR 64	9.82 b (96.00)	8.17 b (68.00)	0.71 a (0)
Situ Patenggang	10.02 c (100)	9.33 b (86.67)	1.18 a (1.33)
Margasari	9.96 b (98.67)	9.55 b (90.67)	1.18 a (1.33)
Towuti	9.62 b (92.00)	7.06 b (49.33)	0.71 a (0)
HSD 0.05		2.95	

(Figures in brackets are the original data, outside the brackets is the data transformation using the arc. sin√x + ½)

Table 5. Theaverage value of growth rate due to the interaction between the PEG 6000 with varieties

	PEG 6000 (%)		
Genotype/Variety	**0**	**12.5**	**25**
Bo Santeut	3.69 c (13.14)	3.69 c (13.14)	0.71 a (0)
Romokot	3.69 c (13.14)	3.54 c (12.03)	0.71 a (0)
Sanbei	3.77 c (13.69)	3.52 c (11.90)	0.71 a (0)
Pade Mas	3.74 c (13.48)	3.28 b (10.39)	0.71 a (0)
Aweuh	3.74 c (13.52)	3.31 b (10.49)	0.93 a (0.39)
Inpari 16	3.82 c (14.09)	3.71 c (13.30)	0.77 a (0.09)
IR 64	3.79 c	3.00 b	0.71 a

Table 6. Average Values of simultaneous growth rate (SGR) due to the interaction with PEG 6000 with varieties

	PEG 6000 (%)		
Genotype/Variety	**0**	**12.5**	**25**
Bo Santeut	9.62 c (92.00)	9.61 c (92.00)	0.71 a (0)
Romokot	9.62 c (92.00)	9.75 c (94.67)	0.71 a (0)
Sanbei	9.82 c (96.00)	9.61 c (92.00)	0.71 a (0)
Padi Emas	9.82 c (96.00)	8.50 b (73.33)	0.71 a (0)
Aweuh	9.75 c (94.67)	9.33 c (86.67)	0.71 a (0)
Inpari 16	9.96 c (98.67)	9.47 c (89.33)	0.71 a (0)
IR 64	9.82 c	7.02 b	0.71 a

	(13.84)	(8.78)	(0)
Situ Patenggang	3.79 c (13.90)	3.42 b (11.21)	0.77 a (0.09)
Margasari	3.82 c (14.09)	3.30 b (10.44)	0.71 a (0)
Towuti	3.69 c (13.08)	2.15 b (4.25)	0.71 a (0)
HSD 0.05		**1.38**	

	(96.00)	(50.67)	(0)
Situ Patenggang	10.02 c (100)	9.26 c (85.33)	0.71 a (0)
Margasari	9.96 c (98.67)	8.55 b (73.33)	0.71 a (0)
Towuti	9.62 c (92.00)	5.45b (29.33)	0.71 a (0)
HSD 0.05		**4.27**	

(Figures in brackets are the original data, outside the brackets is the data transformation using the arc. sin√x + ½)

Table 7. The average value of the interaction between the varieties and concentration of PEG to T50

	PEG 6000 (%)		
Genotype / Variety	**0**	**12.5**	**25**
Bo Santeut	2.00 a	2.33 a	3.33 a
Romokot	2.00 a	2.00 a	3.67 a
Sanbei	2.00 a	2.00 a	3.67 a
Pade Mas	2.00 a	2.67 a	4.00 a
Aweuh	2.00 a	3.00 a	4.33 a
Inpari 16	2.00 a	2.00 a	5.00 a
IR 64	2.00 a	3.00 a	5.33 b
Situ Patenggang	2.00 a	2.00 a	3.33 a
Margasari	2.00 a	2.00 a	6.33 b
Towuti	2.00 a	2.67 a	3.67 a
HSD 0.05		**3.28**	

Table 8. The Average value of dry weight of normal seedling(DWNS) due to interaction between the PEG 6000 with Varieties

	PEG 6000 (%)		
Genotype / Variety	**0**	**12.5**	**25**
Bo Santeut	0.84 a (0.21)	0.84 a (0.21)	0.93 b (0.36)
Romokot	0.88 a (0.27)	0.90 b (0.31)	0.96 c (0.43)
Sanbei	0.90 b (0.32)	0.92 b (0.35)	1.00 c (0.49)
Padi Emas	0.91 b (0.34)	0.94 b (0.39)	1.01 c (0.51)
Aweuh	0.86 a (0.25)	0.89 a (0.29)	0.96 c (0.42)
Inpari 16	0.95 b (0.40)	0.96 c (0.43)	1.06 d (0.63)
IR 64	0.89 a (0.30)	0.94 b (0.38)	1.04 d (0.58)
Situ Patenggang	0.92 b (0.34)	0.94 b (0.39)	1.03 d (0.57)
Margasari	0.88 a (0.28)	0.91 b (0.32)	0.99 c (0.47)
Towuti	0.94 b (0.38)	0.98 c (0.47)	1.05 d (0.61)
HSD 0.05		**0.06**	

(Figures in brackets are the original data, outside the brackets is the data transformation using the arc. sin√x + ½)

From Table 3 to table 8, show that the increasing of PEG 6000 concentration decrease the physiological parameter of seed tested. Local genotype and national release variety has various response in interaction with concentration of PEG 6000. Local Genotype Aweuh, Sanbei, Pade Mas and Romokot have almost the same performance. Inpari 16, Situ Patenggang have better performance than other genotype and variety.

The average value of 50% germination due to the interaction between the varieties and concentration of PEG 6000. At a concentration of 0% PEG 6000 all varieties have the same time to reach 50% germinated seed the same as at PEG 6000 25%, but at a concentration of 12.5% genotype Aweuh, Pade mas, IR 64, Margasari, Towoti need longer time for T50. Genotype Bo Santeut, Sanbei, Inpari 16 and Situ Patenggang have shorter time for T50. In general, respond of Aceh local genotype and national variety of rice tested have the same response at 25% PEG6000. As well as incontrol. But, at 12.5 % PEG 6000. Genotype Bo Santeut, Romokot and Sanbei have the same response which are better than other two genotypes. For national release variety situ patenggang inpari 16 and Margasari have better respond physiologically to cope water stress.

Variative responses above at genotypes and variety to cope water stress because increasing of PEG 6000 concentration response differently by genotype and variety depends on gene spesific response of its genotype and variety. The variety which have gene water stress tolerant which activates enzyme to produce soluble compound in order to cope water stress (Lisar et al, 2013). Decreasing of potential water by increasing PEG 6000 increases activity of NADP_ME(dependent Malic Enzyme) regulates cellular potential hydrogen to keep homoeostasis ion and biosynthetic of organic acid to keep membrane stability and transport electron(Taiz and Zeiger, 2002)

Response of concentration of PEG 6000 at local genotype aceh and national release variety are similar with other research result. At oat, PEG 6000 -0,75 MPa at 8 ° C germination chamber increases median germination time but decrease final germination percentage and root length (Mut *et al*, 2010). PEG 6000 10%-20% decrease maximum germination of rice (Yari *et al*, 2012). PEG 6000 10% and 15% decrease germination percentage (Neshad *et al*, 2013). At -1 and -1.2 MPa decrease plumula length and at -1.2 mPa germination stopped (Toosi *et al*, 2014). PEG 6000 at -1.25 for two days increases MTE (Mean Time Germination) (Solanga *et al*, 2008). PEG 6000 at 15 % decreases germination percentage , at 30% germination of tomato seed stopped (li *et al*, 2014).

Conclusions

Aceh local genotypes were tested and national varieties have different responses to water stress. From the physiological response of genotypes/varieties tested, there are several varieties and genotypes will able to survive in conditions of water stress. A Sanbei local genotype and Pade Mas, and Situ Patenggang varieties have better physiological response with increased water stress induced by increased concentrations of peg 6000.

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